PROTOCOL
FOR
MONITORING EFFECTIVENESS
OF
RIPARIAN PLANTING PROJECTS

MC-3

Washington Salmon Recovery Funding Board

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ORGANIZATION

Riparian habitat improvement projects are popular habitat restoration techniques. They have accounted for 5% of all SRFB projects and are often a subsidiary activity for other categories of projects as well. They have the potential to create improvements in bank stability, streamside shading, erosion, and other benefits within a moderate amount of time (5-20 years).

This document details the monitoring design, procedures, and quality assurance steps necessary to document and report the effectiveness of riparian plantings. This document is in compliance with the Washington Comprehensive Monitoring Strategy (Crawford et al. 2002).

The goal of riparian planting projects is to restore natural streamside vegetation to the stream bank and riparian corridor. The assumption is that riparian vegetation increases shading of the stream, leading to cooler temperatures more desirable for salmon rearing. Vegetative cover also reduces sedimentation and erosion, which can impact egg survival, food organisms, and the ability of salmon to find food.

MONITORING GOAL

Determine whether riparian plantings are effective in restoring riparian vegetation, stream bank stability, and reducing sedimentation.

QUESTIONS TO BE ANSWERED

Have at least 50% of the riparian plantings survived for at least 10 years?

Have the riparian shading and riparian vegetative structure been improved by year 10?

Has bank erosion been significantly reduced by year 10?

NULL HYPOTHESIS

Planting of vegetation in the riparian corridor has had no effect upon:

- Increasing the amount of shading or,
- Increasing the complexity of canopy layers of streamside riparian cover.
- Reducing the proportion of actively eroding streambanks

OBJECTIVES

BEFORE PROJECT (YEAR 0)

Determine the proportion of the three layers of riparian vegetation present within the project impact and control areas.

Determine the proportion of shading within the project impact and control areas.

Determine the proportion of actively eroding stream banks within the project impact and control areas.

AFTER PROJECT (YEARS 1, 3, 5, AND 10)

Determine the overall survival of the species of riparian vegetation planted.

Determine the proportion of the three layers of riparian vegetation present within the project impact and control areas.

Determine the proportion of shading within the project impact and control areas.

Determine the proportion of actively eroding stream banks within the project impact and control areas.

RESPONSE INDICATORS

Level 1-- Number of trees and shrubs planted. The number of trees and shrubs planted at the time of the project. The Level 1 indicator tracks how many plantings actually survived over time as a measure of project effectiveness.

Riparian plantings variable

Indicator Abbreviation	Description
PLANTINGS	The number of planted plants remaining in the impact area
RIPAREA	The area planted with riparian vegetation in the project in acres

Level 2-- Riparian Vegetation. Using EMAP protocols (Peck et al. Unpubl.), the percent shading is calculated using a densitometer and the riparian species diversity understory ground cover and canopy can be determined in a consistent manner. One would expect the percent shading and the species diversity to change over time as the plantings grow. The proportion of actively eroding streambanks is an indicator of sedimentation and erosion into the stream. If riparian plantings are effective in creating riparian cover, then bank erosion should decline.

Riparian vegetation variables

Indicator Abbreviation	Description
XCDENBK	Mean percent shading at the bank (using a densitometer)
XPCMG	Proportion of the reach containing all 3 layers of riparian vegetation, canopy cover, under-story, and ground cover
BANK	Proportion of the reach containing actively eroding stream banks
STRMLGTH	Affected stream length includes meander length affected by the project
CREACHLGTH	The length of the stream control reach actually sampled
CREACHWIDTH	The average stream width of the control reach actually sampled
IREACHLGTH	The length of the stream Impact reach actually sampled
IREACHWIDTH	The average stream width of the Impact reach actually sampled

MONITORING DESIGN

Due to the inter-annual variance in habitat parameters, it is anticipated that at least 10 projects should be sampled in order to provide adequate statistical power to detect change. Approximately 10 riparian planting projects are funded by the SRFB each year. The SRFB intends to monitor 10 projects selected randomly over two consecutive years.

The Board will employ a Before and After Control Impact (BACI) experimental design to test for changes associated with riparian plantings (Stewart-Oaten et al.1986). A BACI design samples the control and impact simultaneously at both locations at designated times before and after the impact has occurred. For this type of restoration, riparian plantings would be the impact and a similar location upstream of the riparian project would represent the control.

For riparian plantings, the BACI design tests for changes in shading, cover levels, and bank erosion of the riparian plantings *relative to* the shading, cover levels, and bank erosion observed at control sites upstream. This type of design is required when external factors (e.g., rainfall and species composition) affect the riparian areas at the control sites. The object is to see whether the difference between impact and control shade, cover levels, and bank erosion have changed as a result of the riparian planting projects. The presence of multiple projects with control and impact locations will address the concerns detailed by Underwood (1994) regarding pseudoreplications. It is also not considered cost effective to employ multiple control locations for each passage project as recommended by Underwood. Although the ideal BACI would have multiple years of before data as well as after data, this was not possible with locally sponsored projects where there is a need and desire to complete their project as soon as possible.

The plan is to compare the most recent time period of sampling with Year 0 conditions, before the projects. A paired *t*-test will be used to test for differences between control (downstream) and impact (upstream) sites during the most recent impact year and Year 0. In other words, we first compute the difference between the control and impact and use those values in a paired *t*-test. This test assumes that differences between the control and impact sites are only affected by riparian plantings and that external influences affect vegetation in the same way at both the control and impact sites. The paired sample *t*-test does not have the same assumptions for normality and equality of variances of the two-sample *t*-test but only requires that the differences be approximately normally distributed. In fact, the paired-sample test is really equivalent to a one-sample *t*-test for a difference from a specified mean value.

To implement the design, we will monitor 10 riparian projects funded in 2003-2004 as part of Round 4 and 5. The number of projects is based upon the calculated sample size needed to obtain statistically significant information in the shortest amount of time.

The variance associated with Impact and control areas will not be known until sampling has occurred in Year 0 of both Impact and control areas. After Year 0, a better estimate of the true sample size needed to detect change will be available. Cost estimates and sampling replicates may need to be adjusted at that time.

At the end of the effectiveness monitoring testing, there will be one year of "before" impact information for all projects for both control and impact areas, and multiple years of "after" impact information for the same control and impact areas for each of the projects.

Depending upon circumstances, the results may also be tested for significance, using a linear regression model of the data points for each of the years sampled and for each of the indicators tested.

Testing for significant trends can begin as early as Year 1. Final sampling may be completed in 2008.

DECISION CRITERIA

Effective if at least 50% of the riparian plantings in the project area survived in Year 10.

Effective if a change of 20% or more is detected by Year 10 at the Alpha=0.10 level for measures of the mean percent canopy density and the mean proportion of the three layers of riparian vegetation presence for the calculated difference between the paired Impact and control areas.

Table 1. Decision criteria for riparian plantings.

Habitat	Indicators	Metric	Test Type	Decision Criteria
Plantings	The number of planted plants remaining in the impact area (PLANTINGS)	#	None. Count of live plantings	≥ 50% of plantings are living by Year 10
Riparian Condition	Mean percent canopy density at the bank Densitometer Reading (XCDENBK)	1-17 score	Linear Regression or Paired *t*-test	Alpha =0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10
	3-layer riparian vegetation presence (proportion of reach) (XPCMG)	%	Linear Regression or Paired *t*-test	Alpha =0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10
	Actively eroding banks (BANK)	%	Linear Regression or Paired *t*-test	Alpha =0.10 for one-sided test. Detect a minimum 20% change between impact and control by Year 10

SAMPLING

SELECTING SAMPLING REACHES

IMPACT AREA

Riparian plantings are often not very large and an impact reach should be sampled according to the methods detailed on page 13.

CONTROL AREA

A control reach distributed upstream of the project site should be selected and designed in the same manner as the impact reach. The control should consist of a distance of equal size and habitat type immediately upstream of the project site.

BEFORE PROJECT SAMPLING

All riparian plantings projects identified for long-term monitoring by the SRFB must have completed pre-project Year 0 monitoring prior to beginning the project. Year 0 monitoring will consist of:

- Determining the acreage and linear distance in kilometers to the nearest tenth of riparian shrubbery to be planted.
- Measure the riparian vegetation structure for the project impact and control area, including canopy cover and density measurements. The riparian vegetation is divided into three layers: canopy layer (>5m high), understory (0.5 to 5m high), and ground cover (<0.5m high).
- Measure the proportion of the streambanks within the projects impact and control area.

AFTER PROJECT SAMPLING

Upon completion of the project, Years 1, 3, 5, and 10 monitoring will consist of:

- Enumerating surviving planted trees and shrubs. The goal of the project is to increase trees and shrubs in the riparian zone. Therefore, post-project sampling will consist of evaluating survival of planted tree and shrubs within the project area. If additional plantings occur after the beginning of the project, these should be noted and included in the analysis.
- Measure the riparian vegetation structure for the project impact and control area including canopy cover density measurements vegetation structure.
- Measure the proportion of the streambanks within the projects impact and control area.

METHOD FOR QUANTIFYING RIPARIAN PLANTINGS

Protocol adapted from: ***New Zealand National Vegetation Survey (2004); Greening Australia Federation (2004); Wishnie et al. (1999)***

PURPOSE

This protocol is to be implemented after a habitat restoration project funded by the SRFB has placed vegetative plantings along the riparian corridor. The intent is to trace the survival, condition, and growth of the riparian plantings. Riparian restoration plantings may be a mixture of evergreen and hardwoods tolerant to riparian areas. In reforestation areas tree densities of 400-700 trees per acre are commonly used at the time of planting. It is normally anticipated that tree loss will occur and that after 3-5 years 50% or more will have succumbed to competition, browsing or some other effect. Normal timberlands in the Pacific Northwest thinned for wood production will contain 30 trees/acre for Douglas fir and up to 60 trees per acre for planted hemlock and alder. For the purposes of testing effectiveness over a relatively short period of ten years, there could be expected to be approximately 200 trees per acre at the end of the study.

EQUIPMENT

Orthophoto if available, handheld GPS device, 50 m tape measure, 2 ft. steel rebar stakes, 8 ft. ½ inch pvc pole, engineer flagging tape, appropriate waterproof field forms, aluminum write on tags, plastic locking ties, Vernier caliper, DBH tape, (optional coded wire tags [CWT] or radio frequency identification tags [RFID]).

PROCEDURE

Step 1: Determine the overall area (acres) of riparian plantings by marking the boundaries using a **GPS device**, and by using a **metric tape measure** or calibrated ortho-photo. Mark the boundaries of the planting with **2 foot steel rebar stakes** driven solidly into the ground at the 4 corners.

Step 2: The field crew should select 10 random points throughout the plantings and construct a 201ft^2 circular plot using an **8' pole**. A 2 ft. piece of rebar should be driven into the ground and flagged with **engineer tape** and its location recorded using GPS. Stand at the stake at the center of the randomly selected point and describe a circle with the pole. As you turn, count the plantings which fall under the pole. Calculate the average number of plantings per plot and multiply that figure by 216.65 to give the average number of plantings per acre.

Average Θ = (s1 + s2 + s3 + s4…. +s10)/10
Variance = [(s1- Θ)2 + (s2 – Θ)2 +…(s10 – Θ)2]/10-1
Density (acres) = Average s X 216.65 = trees/acre

Step 3: For each planting sampled within a permanent plot, the following steps should be performed:

a. Record the project site, plot number, and date.
b. Assign a sequential number to each planting.
c. Record the species using the appropriate USFS species code.
d. Measure the height of each planting in feet from the highest point to the ground. If the planting is leaning to one side, measure from the highest point down to a point level with the base of the stem, not along the stem itself and record into the data sheet.
e. Tag the planting (trees only). Tagging will be accomplished using an **aluminum write on tag** produced by Lab Safety Supply or similar metal tag attached bar locked loosely to the stem above the first whorl. At some locations a **coded wire tag or RFID** may be imbedded into the seedling to test whether positive identification of a tree planting can be obtained over time as the tree grows.

f. Using a **Vernier caliper** or **DBH tape** determine the DBH class for each planting. DBH classes are as follows
   1) 0.0”- 2.5” = 1
   2) 2.6” – 5.0” = 2
   3) 5.1” – 10.0” = 3
   4) 10.1” – 15.0” =4
   5) 15.1” – 20.0” = 5
   6) 20.1” – 25.0” = 6
   7) 25.1” – 30.0” = 7
   8) >30.1” = 8

g. Determine brush competition using the appropriate brush competition code for each planting.
h. Classify grass competition using the appropriate grass code.
i. Classify browse damage using the appropriate browse classification code.
j. Record whether the planting is alive (A) or dead (D).

Step 4: Repeat Step 2 and 3 on Year 3, 5, and 10.

Table 2. Seedling condition codes

Category	Points	Description
Brush Competition		
	0	No brush shading or within 2 ft.
	1	Brush within 2 ft. and shading <25%
	2	Brush within 2 ft. and shading 25-50%
	3	Brush within 2 ft. and shading > 50%
Grass Competition		
	0	No sod within 2 ft.
	1	Sod within 12 in.
	2	Sod within 6 in.
	3	Sod to stem
Browse damage		
	0	No browse damage
	1	Terminal leader not browsed, less than 1/3 lateral branches browsed
	2	Terminal leader not browsed, 1/3-2/3 lateral branches browsed
	3	Terminal leader not browsed, > 2/3 lateral branches browsed
	4	Only terminal leader browsed
	5	Terminal leader browsed, less than 1/3 lateral branches browsed
	6	Terminal leader browsed, 1/3-2/3 lateral branches browsed
	7	Terminal leader browsed, > 2/3 lateral branches browsed
	8	Girdled and/or cut off stems

	Project #							
	Worksite				**Plot #**			
					Longitude			
	Date				**Latitude**			
	Tree Tag# / CWT/RFID	**Species Code**	**Height (ft)**	**DBH (inches)**	**Brush Code**	**Grass Code**	**Browse Code**	**Dead/Alive D/A**
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
	Shrubs	**Species Code**	**#/Plot**		**Shrubs**	**Species Code**	**#/Plot**	
1					**5**			
2					**6**			
3					**7**			
4					**8**			

Figure 1. Riparian planting field form

METHOD FOR LAYING OUT CONTROL AND IMPACT STREAM REACHES FOR WADEABLE STREAMS

Protocol taken from: ***Peck et al. (Unpubl.), pp. 63-65, Table 4-4; Mebane et al. (2003)***

EQUIPMENT

Metric tape measure, surveyor stadia rod, handheld GPS device, 3 - 2 ft. pieces of rebar painted bright orange, engineer flagging tape, waterproof markers

SAMPLING CONCEPT

The concept of EMAP sampling is that randomly selected reaches located on a stream can be used to measure changes in the status and trends of habitat, water quality, and biota over time if taken in a scientifically rigorous manner per specific protocols. We have applied the EMAP field sampling protocols for measuring effectiveness of restoration and acquisition projects. Instead of a randomly selected stream reach, the stream reach impacted by the project is sampled. These “impact” areas have been matched with “control” areas of the same length and size on the same stream whenever possible.

Within each sampled project reach a series of transects A-K are taken across the stream and riparian zone as points of reference for measuring characteristics of the stream and riparian areas. The transects are then averaged to obtain an average representation of the stream reach.

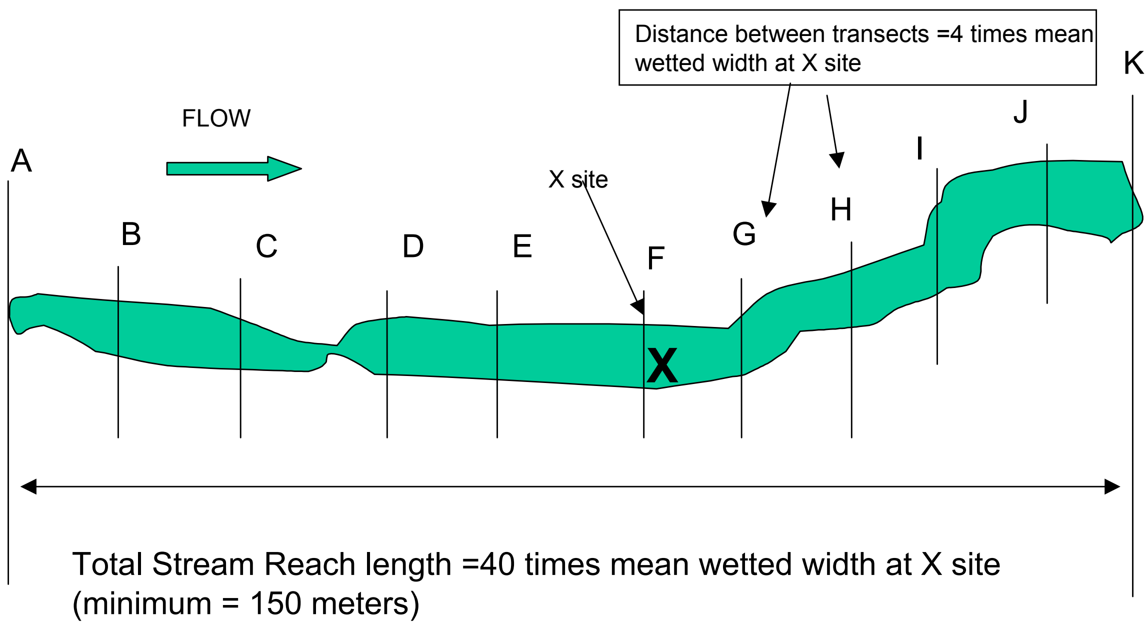

Figure 2. Sampled project reach

LAYING OUT THE TREATMENT AND CONTROL STREAM REACHES

Step 1: Using a handheld GPS device, determine the location of the **X sites** and record latitude and longitude of same on waterproof sheets. The X sites should be considered the center of the impact and control study reach. The Impact reach X site must fall within the project affected area. The location of the control X site should be determined based upon the project category and associated procedure (MC-1 to MC-10). Mark the X site on the bank above the high water mark with one of the rebar stakes so that the X site can be found in future years. Use a surveyor's rod or tape measure to determine the wetted width of the channel at five places considered to be of "typical" width within approximately five channel widths upstream and downstream of the X site sample reach location. For streams less than 4 m in width the reach should be at minimum 150 m.

Step 2: Check the condition of the stream upstream and downstream of the X site by having one team member go upstream and one downstream. Each person proceeds until they can see the stream to a distance of 20 times the stream width (equal to one half the sampling reach length) determined in Step 1.

For example if the reach length is determined to be 150 m, each person would proceed 75 m from the X site to lay out the reach boundaries.

NOTE: *For restoration projects less than 40 stream widths, the entire project's length should be sampled and a control area of similar size should likewise be developed within the treatment stream either upstream or downstream as appropriate.*

Step 3: Determine if the reach needs to be adjusted around the X site due to confluences with lower order streams, lakes, reservoirs, waterfalls, or ponds. Also adjust the boundaries to end and begin with the beginning of a pool or riffle, but not in the center of the pool or riffle. Hankins and Reeves (1988) have shown that measures of the variance of juvenile fish populations is decreased by using whole pool/riffles in the sample area.

Step 4: Starting back at the X site, measure a distance of **20 channel widths** down one side of the stream using a tape measure. Be careful not to cut corners. Enter the channel to make measurements only when necessary to avoid disturbing the stream channel prior to sampling activities. This endpoint is the downstream end of the reach and is flagged as transect "A".

Step 5: Using the tape, measure 1/10th (4 channel widths in big streams or 15 m in small streams) of the required stream length upstream from the start point (transect A). Flag this spot as the next cross section or transect (transect B).

Step 6: Proceed upstream with the tape measure and flag the positions of nine additional transects (labeled "C" through "J" as you move upstream) at intervals equal to 1/10th of the reach length.

METHOD FOR CHARACTERIZING RIPARIAN VEGETATION STRUCTURE

Protocol taken from: ***Peck et al. (Unpubl.), Table 7-10; Kauffman et al. (1999)***

PURPOSE

This protocol is designed to determine the changes in riparian vegetation due to a restoration project where riparian vegetation has been planted.

EQUIPMENT

Convex spherical densitometer, field waterproof forms.

SITE SELECTION

The sample reaches are those laid out according to the methods on page 13.

SAMPLING DURATION

Sampling should occur during July-August when vegetation is at its maximum growth.

PROCEDURES FOR MEASURING RIPARIAN VEGETATION AND STRUCTURE

Following are taken from Table 7-10 of EMAP protocols:

1. Standing in mid-channel at a cross-section transect (A-K), estimate a 5m distance upstream and downstream (10m length total).
2. Facing the left bank (left as you face downstream), estimate a distance of 10m back into the riparian vegetation or until an exclosure is encountered. On steeply sloping channel margins, estimate the distance into the riparian zone as if it were projected down from an aerial view.
3. Within this 10 m X 10 m area, conceptually divide the riparian vegetation into three layers: a canopy layer (>5 m [16ft] high), an understory (0.5 to 5 m [20 inches to 16ft.] high), and a ground cover layer (<0.5 m high).
4. Within this 10 m X 10 m area, determine the dominant vegetation type for the canopy layer as either **Deciduous, Coniferous, broadleaf Evergreen, Mixed, or None.** Consider the layer mixed if more than 10% of the areal coverage is made up of the alternate vegetation type. Indicate the appropriate vegetation type in the “Visual Riparian Estimates” section of the Channel/Riparian Cross Section Form.
5. Determine separately the areal cover class of large trees (>0.3 m [1ft] diameter breast height [DBH]) and small trees (<0.3m DBH) within the canopy layer. Estimate areal cover as the amount of shadow that would be cast by a particular layer alone if the sun were directly overhead. Record the appropriate cover class on the field data form (**“0”= absent: zero cover, “1”= sparse: <10%, “2”= moderate: 10-40%, “3”=heavy: 40-75%, or “4”= very heavy: >75%)**.
6. Look at the understory layer. Determine the dominant vegetation type for the understory layer as described in Step 4.
7. Determine the areal cover class for woody shrubs and saplings separately from non-woody vegetation within the understory, as described.
8. Look at the ground cover layer. Determine the areal cover class for woody shrubs and seedlings, non-woody vegetation, and the amount of bare ground present as described in Step 5 for large canopy trees.
9. Repeat steps 1 through 8 for the right bank.
10. Repeat steps 1 through 9 for all cross-section transects, using a separate field data form for each transect.

Table 3. Field data form for recording visual riparian estimates. One form for each transect A-K.

Riparian Vegetation Cover	Left Bank					Right bank					Flag
	Canopy (> 5m high)										
Vegetation type	**D**	**C**	**E**	**M**	**N**	**D**	**C**	**E**	**M**	**N**	
Big trees (trunk > 0.3m DBH) XCL	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
Small trees (trunk ,0.3m DBH) XCS	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
	Understory (0.5 to 5m high)										
Vegetation type	**D**	**C**	**E**	**M**	**N**	**D**	**C**	**E**	**M**	**N**	
Woody shrubs and saplings XMW	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
Non-woody herbs grasses and forbs XMH	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
	Ground cover (,0.5m high)										
Woody shrubs & saplings XGW	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
Non-woody herbs grasses and forbs XGH	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
Barren dirt or duff XGB	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	

Following table taken from Kauffman et al. (1999) details the parameter codes and precision metrics of EMAP procedures conducted in Oregon. Parameters in bold type are the most precise. This table is provided for information purposes only.

Code	Variable name and description	RMSE = σ_{rep}	CV = σ_{rep} / ”(%)	S/N = $\sigma^2_{st(yr)}$ / σ^2_{rep}
XCL	Large diameter tree canopy cover (proportion of riparian)	0.057	38	4.6
XCS	Small diameter tree canopy cover (proportion of riparian)	0.12	55	1.4
XC	**Tree canopy cover (proportion of riparian)**	**0.12**	**33**	**2.4**
XPCAN	**Tree canopy presence (proportion of riparian)**	**0.08**	**8.7**	**10**
XMW	Mid-layer woody vegetation cover (proportion of riparian)	0.12	41	0.9
XMH	Mid-layer herbaceous vegetation cover (proportion of riparian)	0.13	100	0.9
XM	**Mid-layer vegetation cover (proportion of riparian)**	**0.19**	**44**	**0.6**
XPMID	**Mid-layer vegetation presence (proportion of riparian)**	**0.03**	**3.5**	**2.1**
XGW	Ground layer woody vegetation cover (proportion of riparian)	0.17	77	0.1
XGH	Ground layer herbaceous vegetation cover (proportion of riparian)	0.16	40	1.1

XGB	Ground layer barren or duff cover (proportion of riparian)	0.07	47	2.0
XG	Ground layer vegetation cover (proportion of riparian)	0.22	36	0
PCAN_C	Conifer riparian canopy (proportion of riparian)	0.11	58	8.5
PCAN_D	Broadleaf deciduous riparian canopy (proportion of riparian)	0.13	31	7.4
PCAN_M	Mixed conifer-broadleaf canopy (proportion of riparian)	0.16	65	2.9
PMID_C	Conifer riparian mid-layer (proportion of riparian)	0.02	55	37
PMID_D	Broadleaf deciduous riparian mid-layer (proportion of riparian)	0.33	58	0.7
PMID_M	Mixed conifer-broadleaf canopy (proportion of riparian)	0.32	87	0.6

PROCEDURES FOR MEASURING CANOPY COVER

Canopy cover is determined for the stream reach in the treatment and control areas at each of the 11 cross-section transects. A convex spherical Densitometer (Model B) is used. Six measurements are obtained at each cross section transect at mid-channel

1. At each cross-section transect, stand in the stream at mid-channel and face upstream.
2. Hold the Densitometer 0.3 m (1 ft.) above the stream. Hold the Densitometer level using the bubble level. Move the Densitometer in front of you so that your face is just below the apex of the taped “V”.
3. Count the number of grid intersection points within the “V” that are covered by either a tree, a leaf, or a high branch. Record the value (0-17) in the CENUP field of the canopy cover measurement section of the form.
4. Face toward the left bank (left as you face downstream). Repeat steps 2 and 3, recording the value in CENL field of the data form.
5. Repeat steps 2 and 3 facing downstream, and again while facing the right bank (right as you look downstream). Record the values in the CENDWN and CENR fields of the field data form.
6. Repeat steps 2 and 3 again, this time facing the bank while standing first at the left bank, then the right bank. Record the value in the LFT and RGT fields of the data form.
7. Repeat steps 1-6 for each cross-section transect (A-K). Record data for each transect on a separate data form.
8. If for some reason a measure cannot be taken, indicate in the “Flag” column.

Location	1-17	Flag
CENUP		
CENL		
CENDWN		
CENR		
LFT		
RGT		

Figure 3. Form for tallying canopy density

Each of the measures taken at the center of the stream are summed for all 11 transects and converted to a percentage based upon a maximum score of 17 per transect. The results are then averaged to produce a mean % canopy density at mid-stream (XCDENMID).

Each of the measures taken at the banks of the stream are summed for all 11 transects and converted to a percentage based upon a maximum score of 17 per transect. The results are then averaged to produce a mean % canopy density at the stream bank (XCDENBK).

Each of the measures are totaled and averaged to produce the following table of riparian vegetative cover.

Table 4. The shaded composite variables are considered the most important in terms of their precision and are the ones that will be used to determine effectiveness of riparian plantings.
RMSE = σ_{rep} is the root mean square error. The lower the value, the more precise the measurement.
CV σ_{rep} / ”(%) is the coefficient of variation. The lower the number, the more precise the measurement.
S/N = $\sigma^2_{st(yr)}$ / σ^2_{rep} is the signal to noise ratio. The higher the number, the more that metric is able to discern trends or changes in habitat in a single or multiple sites. This table is provided to demonstrate the best indicators for testing significance.

Variable	Description	RMSE = σ_{rep}	CV = σ_{rep} / ”(%)	S/N = $\sigma^2_{st(yr)}$ / σ^2_{rep}
XCDENBK	Mean % canopy density at bank (Densitometer reading)	3.9	4.4	17
XC DENMID	**Mean % canopy density mid-stream (Densitometer reading)**	**5.8**	**8.1**	**15**
XCM	Mean riparian canopy + mean mid-layer cover	0.22	33	1.4
XPCM	Riparian canopy and mid-layer presence (proportion of reach)	0.08	9.8	7.9
XPCMG	**3-layer riparian vegetation presence (proportion of reach)**	**0.08**	**9.8**	**8.0**

METHOD FOR MEASURING ACTIVELY ERODING STREAMBANKS

Protocol taken from: ***Moore et al. (1998)***

PURPOSE

The protocol will allow us to determine if the stream banks within the habitat restoration area have improved and thereby reduced siltation and erosion by reducing the percentage of the streambank that is actively eroding.

EQUIPMENT

Appropriate waterproof sampling form, waders or hip boots.

SITE SELECTION

The sample reaches are those laid out according to the methods on page 13.

PROCEDURE

Estimate the percent of the lineal distance of both sides of the transect that is actively eroding at the active channel height. Active erosion is defined as actively, recently eroding or collapsing banks and may have the following characteristics: exposed soils and inorganic material, evidence of tension cracks, active sloughing, or superficial vegetation that does not contribute to bank stability.

Transect	Left Bank	Right Bank
A		
B		
C		
D		
E		
F		
G		
H		
I		
J		
K		
Total (sum left & right bank)		
Mean Percent erosion (total/22)		
Variance		

Figure 4. Bank erosion form. Percent erosion.

TESTING FOR SIGNIFICANCE

We can create a table resembling the following from the data collected for each of the indicators for number of riparian plantings, canopy cover, understory, ground cover, and canopy.

Table 5. Example - Data table for hypothetical presence of riparian plantings.

	Year 0 # AIS installed	Year 1	Year 3	Year 5	Year 10
	Impact	**Impact**	**Impact**	**Impact**	**Impact**
Proj. 1	**0**	**200**	**190**	**170**	**160**
Proj. 2	**0**	**50**	**44**	**36**	**22**
Proj. 3	**0**	**1000**	**882**	**796**	**600**
Proj. 4	**0**	**250**	**249**	**233**	**120**
Proj. 5	**0**	**90**	**44**	**23**	**7**
Proj. 6	**0**	**450**	**428**	**401**	**336**
Proj. 7	**0**	**2000**	**1884**	**1588**	**1109**
Proj. 8	**0**	**100**	**91**	**72**	**55**
Proj. 9	**0**	**200**	**187**	**152**	**109**
Proj.10	**0**	**1500**	**1443**	**1103**	**932**
Total	**0**	**5840**	**5442**	**4574**	**3450**
Percent Remaining	**0**	**100**	**93**	**78**	**59**

Table 6. Mean % canopy density at bank (Densitometer reading).

	Year 0 2003		Year 1 2005		Year 3 2006		Year 5 2008		Year 10 2014	
	Impact	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**
Proj. 1										
Proj. 2										
Proj. 3										
Proj. 4										
Proj. 5										
Proj. 6										
Proj. 7										
Proj 8										
Proj 9										
Proj 10										
Sum										
Mean										
Var.										
% Change										

Among all of the measures taken in the riparian area under EMAP sampling protocols, two measures demonstrate the greatest precision and signal to noise ratio (see Table 7). These are the mean percent canopy density at bank (Densitometer reading) and the 3-layer riparian vegetation presence (proportion of reach). We wish to test whether the percentage of the area with 3-layer riparian vegetation presence has increased significantly post impact.

We also wish to test whether the mean percent canopy density at bank has increased significantly in the treated area post impact.

Table 7. Composite variable exhibiting the best all-around precision and signal to noise ratios. RMSE = σ_{rep} is the root mean square error. The lower the value, the more precise the measurement. CV σ_{rep} / ”(%) is the coefficient of variation. The lower the number, the more precise the measurement. S/N = $\sigma^2_{st(yr)}$ / σ^2_{rep} is the signal to noise ratio. The higher the number, the more that metric is able to discern trends or changes in habitat in a single or multiple sites. Table provided for information purposes only.

Variable	Description	RMSE = σ_{rep}	CV = σ_{rep} / ”(%)	S/N = $\sigma^2_{st(yr)}$ / σ^2_{rep}
XCDENBK	**Mean % canopy density at bank (Densitometer reading)**	**3.9**	**4.4**	**17**
XC DENMID	Mean % canopy density midstream (Densitometer reading)	5.8	8.1	15
XCM	Mean riparian canopy + mean mid layer cover	0.22	33	1.4
XPCM	Riparian canopy and mid layer presence (proportion of reach)	0.08	9.8	7.9
XPCMG	**3-layer riparian vegetation presence (proportion of reach)**	**0.08**	**9.8**	**8.0**

Table 8. 3-layer riparian vegetation presence (proportion of reach).

	Year 0 2003		Year 1 2005		Year 3 2006		Year 5 2008		Year 10 2014	
	Impact	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**	**Impact**	**Cntrl**
Proj. 1										
Proj. 2										
Proj. 3										
Proj. 4										
Proj. 5										
Proj. 6										
Proj. 7										
Proj 8										
Proj 9										
Proj 10										
Sum										
Mean										
Var.										
% Change										

The data will be tested using a paired *t*-test. The paired *t*-test is a very powerful test for detecting change because it eliminates the variability associated with individual sites by comparing each stream to itself, that is, at impact and control locations within the same stream. The impact reach and control reach for each stream are affected by the same local environmental factors and local characteristics in the flora and fauna in contrast with other stream systems with their own unique environmental conditions. In other words, the two observations of the pair are related to each other.

Because the paired *t*-test is such a powerful test for detecting differences, very small differences may be statistically significant but not biologically meaningful. For this reason, biological significance will be defined as a 20% increase in shading and vegetation at the Impact sites. The statistical test will be one-sided for an Alpha=0.10. We use a one-sided test because a significant decrease in salmon abundance after the impact of the project would not be considered significant, that is, the project would not be considered effective. In other words, we are not interested in testing for that outcome. The test will be conducted in Years 1, 3, 5, and 10. If the results are significant in any of those years, the riparian projects will be considered effective.

Our conclusions are, therefore, based upon the differences of the paired scores for the 10 sampled riparian projects. Though somewhat confusing, it may be helpful to think of the statistic as the "difference of the differences". A one-tailed paired-sample *t*-test would test the hypothesis:

H_0 : The mean difference is less than or equal to zero.
H_A : The mean difference is greater than zero.

The test statistic is calculated as:

$$t_{n-1} = \frac{đ - 0}{S_{đ}}$$

where
đ = mean of the differences for Year 0 and a subsequent year

$S_{đ}$ = variance of the differences

$S_{đ} = S_d / n^{1/2}$ = variance mean

n = number of sites (or site pairs).

DATA MANAGEMENT PROCEDURES

Data will be collected in the field using various hand-held data entry devices. Raw data will be kept on file by the project monitoring entity. A copy of all raw data will be provided to the SRFB at the end of the project. Summarized data from the project will be entered into the PRISM database after each sampling season. The PRISM database contains data fields for the following parameters associated with these objectives.

Table 9. Riparian Plantings Project Level PRISM Data.

Indicator	Metric	Pre Impact Year 0	Post Impact Year 1	Post Impact Year 3	Post Impact Year 5	Post Impact Year 10
Stream Distance affected by plantings	miles	√				
Total area affected	acres	√				
Plantings present	#	√	√	√	√	√
Riparian Canopy Covers Impact	Mean % canopy density at the bank	√	√	√	√	√
Riparian Canopy Covers Control	Mean % canopy density at the bank	√	√	√	√	√
Statistically significant	Yes/No			√	√	√

Indicator	Metric	Pre Impact Year 0	Post Impact Year 1	Post Impact Year 3	Post Impact Year 5	Post Impact Year 10
Riparian Cover Impact	Proportion of Impact reaches where 3 vegetation layers are present	√	√	√	√	√
Riparian Cover Control	Proportion of control reaches where 3 vegetation layers are present	√	√	√	√	√
Statistically significant	Yes/No		√	√	√	√
Bank Stability Impact	Mean % of stream bank	√	√	√	√	√
Bank Stability Control	Mean % of stream bank	√	√	√	√	√
Statistically significant	Yes/No		√	√	√	√

REPORTS

PROGRESS REPORT

A progress report will be presented to the SRFB in writing by the monitoring entity after the sampling season for Years 1 and 5.

FINAL REPORT

A final report will be presented to the SRFB in writing by the monitoring entity after the sampling season for Year 10. It shall include:

- Estimates of precision and variance.
- Confidence limits for data.
- Summarized data required for PRISM database.
- Determination whether project met decision criteria for effectiveness.
- Analysis of completeness of data, sources of bias.

Results will be reported to the SRFB during a regular meeting after 1, 3, 5, and 10 years post project. Results will be entered in the PRISM database and will be reported and available on the Interagency Committee for Outdoor Recreation website and the Natural Resources Data Portal.

ESTIMATED COST

It is estimated that 33 man-hours will be needed to complete each project site (control and impact). Cost estimate using 2004 rates are $2,500 - $3,500 per site.

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